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>> The hearing of the energy subcommittee of the science committee will come to order. Recognize myself for five minutes for an opening statement. I want to welcome everybody here to this hearing of the energy subcommittee of the House science committee and on the status of efforts to develop renewable energy technologies and expand their use in the United States and around the world. It's an honor for me to be in California in the district of my friend and colleague, and the ranking member of this subcommittee, Mr. Honda. Thank you. And I hope we make life a little easier by bringing this hearing across the continent to you, rather than making you come to Washington today where the temperature is expected to be 102. There's no better place to explore the contributions of energy research than here in the golden state of California. California has made extensive work of hydro, geothermal, and wind resources, which contribute 10% of the state's energy resources, rather than 2% nationally. We have a way to go. California has each of these renewable errors -- resources. I can't say that is true of my home state of Illinois. It is too flat, it has no geothermal resources, unless you count some of the tunnels that run under the city of Chicago. And when the sun shines, it doesn't shine enough. And when the windy city has a renewable resource that is its namesake, only capturing the strong and volatile winds in Chicago and other parts of the state. When you say renewable energy in Illinois most people think of corn and ethanol and soybeans and biodiesel. Renewable energy is a growing industry and we are taking it very seriously. Government resources in renewable increase in Europe and Japan have meant growing market shares for the world and solar generation equipment for those countries. While the U.S. market share is declining as a nation we can't afford to sit on the sidelines. That's why I introduced HR 5656, a bill that focuses efforts on some of the greatest challenges on expanding renewable energy. Among other things the bill directs researchers to direct their efforts to make solar energy cost competitive by 2015. In addition the bill would establish a program to demonstrate advanced solar technologies in every state. In this way we may learn to capture the powers of the sun in Illinois in the winter time. In addition to targeting federal research efforts at improving the efficiency of turbines and the cost effectiveness of wind power, the bill also supports the development of the genetic efficiency of making ethanol from biomass rather than corn. As we discuss our investment in this kind of renewable energy, the challenge is to make sure that we not forget the demand side of the equation. Energy use of all kinds have environmental consequences. We should be aware of them, understand the tradeoffs and make decisions that are fully informed by the facts. That is why renewable energy R&D the topic of our hearing today is so timely. Americans want affordable energy, and a clean and safe environment, and yet because we've undervalued the renewable increase resource, we act as though the two are mutually exclusive. This is not true of the witnesses we will hear from today. They understand the potential technologies. They invested in the renewable R&D, some independently and some in partnership with the federal government but in all cases they have success stories. I want to thank this remarkable accomplished panel for sharing their insight with us, with the development of renewable energy generation both domestically and in developing countries. Before I introduce our panel I'd like to turn to the subcommittee's distinguished ranking member Mr. Honda for his opening statement. Gentleman is recognized for five minutes.

>> Thank you, madam chair and welcome to San José and also, welcome back close to the site of your alma mater, Stanford university. I know that you are enjoying our wonderful weather, and maybe we can talk a little bit more to our witnesses. I'd like to thank everyone for being here for this hearing about a topic that I believe is essential to the future of our nation, our world which is renewable energy. Chair, I thank you for traveling out to Silicon Valley to hear what these people have to contribute to this wonderful endeavor. I thank Cindy Chavez, who made it possible for having this hearing in this wonderful space today. Cindy, would you stand up and be recognized, I want to thank you and your council for receiving

us here today. It's a wonderful friendly natural lit chambers. I also want to thank all the witnesses for agreeing to testify before us today. I think we have assembled an eminently qualified panel that demonstrates the breadth of Silicon Valley, the place it is. I drive a hybrid car. I'm also in the process of doing some work in my house and my plans involve installing solar photovoltaics on the roof. Sadly, the rest of the nation isn't doing the same. The United States was once leader in solar technology. Last year only 11% of the photovoltaic generating capacity was manufactured here. Our track record at installing solar generation is equally poor. By the end of 2004 the United States total installed photovoltaic generating capacity was only equal to what a standard coal fired power plant produces or approximately 4/100ths of 1% of the United States production. Solar installation in Japan increased by use of meaningful government incentive programs. All is not lost because nature gives us an advantage. The United States has a far greater potential for solar power than Germany and that means that the U.S. has tremendous growth potential for solar energy. Here in California we are taking the lead with over 100 megawatts installed capacity. Photovoltaic system is not cheap to purchase and to install. To succeed in advancing solar technology cost must be reduced. Fortunately as more cells are manufactured the cost has decreased 5 to 7% per year. As more consumers install these systems with the help of federal and state incentives price will continue to fall and the cost of power will become comparable to other sources. Research and development can help to increase the efficiency and decrease the cost of renewable energy. For example in the area of biofuel, research can help develop crops that are easy to sustain and produce greater energy yields. In the area of photovoltaics new field such as nanotechnology offer the opportunity to develop solar cells that can be used to generate electricity and collect all light more efficiently. With the right resources the global scientific and energy community can continue down the path to progress. It needs to be a global event because developing countries don't have the luxury of thinking about expensive energy solutions. For the poorest countries energy is the source of their poverty. 38 of the poorest countries are net importers of oil and 25 of them import all of their oil. At oil prices over $70 per barrel these countries are being disproportionately impacted. Renewable energy in its various forms have many characteristics that make it usable in the developing world as well as here in the U.S. Usable electricity that generate power where it is needed means that large investments in infrastructure can be avoided. In developing countries, distributive generation is essential to rapid success and that's where infrastructure links between rural communities and remote settlements are not well developed. Photovoltaic thees and small wind generation are well suited for distributed generation results, because they can be installed in remote locations and can be scaled to whatever the local energy needs are. Biofuels can capitalize on the agriculture stage of other countries. Improving the situation of small farmers who cannot compete in the global market as it exists today. Brazil is a great example of how nations can use agriculture to make energy a source of opportunity rather than a source of oppression. I notice when I was in last year I noticed how Brazilian government has, ethanol a common source of fuel. By the end of last year 70% of the new cars sold in Brazil were flex fuel vehicles. Like the ones that the chairwoman and I saw in her field hearing in Illinois in June, that vehicle can use ethanol as well as gasoline. In our job one of the things that we have to worry about is international relations. Both energy and climate change are pieces of this bigger picture. Fortunately, renewable energy offers opportunities to make this bigger picture a little bit less complicated. When developing countries depend on other countries they are unable to invest in improvements within leading to humanitarian crisis which require international responses and human suffering. Using renewable energy, developing energies could instead use their own living resources to power their development and enhance their economies. Throughout history wars have been fought over nonrenewable natural resources. In a world focused on using renewable energy, these conflicts could be avoided and greatest ability achieved. But

we need to convince consumers here and in developing countries to choose to adopt renewable energies but to do so we need to make them cost effective and improve their performance. I look forward to the insights that the witnesses will provide today to a lively discussion following the testimony. Thanks again to everyone who has appeared today and I yield back my time.
>> Thank you very much Mr. Honda. Any extension of remarks may be added to the record. At this time I'd like to introduce all of our witnesses and thank you for coming to joins us today. We'll start with Dr. Steven Chu the director of Lawrence Berkeley national laboratory and a 1997 Nobel Prize winner. In physics. He is currently spearheading a new laboratory initiative focused on solar energy. We have Dr. Arno Penzias, a venture partner with new enterprise associates in Palo Alto. While at bell laboratories he won the Nobel Prize for physics in 1978. Today he is a venture capitalist with interest in renewable energy technologies. Mr. Christian Larsen is vice president for generation for the electric power research institute in Palo Alto. His division provides data on cost and performance analyses and for renewable distributed and hydropower energy technologies to the electricity industry. Mr. David Pearce is president and CEO of Miasolé, I hope I'm close, a Santa Clara based company that manufactures strum scale solar products using thin film solar cell technology developed in the Department of Energy national laboratories. And finally Mr. Ron Swenson is co-owner of ElectroRoof and EcoSage, developing a program to build solar powered satellite teaching centers in remote sections of the world. In conjunction with solar programs in schools. And with that, I'll turn over to our ranking member Mr. Honda for introductions.
>> Thank you madam chair. Just very quickly, I'd like to acknowledge that we have Coleman 40 Williams, Councilmember from Sunnyvale, Chris Moyman, who is also a high-tech guy, and we have Vern Meechham and our vice chair, Cindy Chavez, who secured this place for us. Thank you ma'am chair.
>> Three minutes and five minutes in rotation. We will begin with Dr. Chu. Dr. Chu, if you could turn on your microphone.
>> Better, thank you, chairman, ranking member Honda and members of the committee. It's a great pleasure that I'm here again to testify before the house science committee on this issue of critical importance. The last time I was here I was testifying on behalf of the national academy of sciences report chaired by Norm Augustine known as the rise of the gathering storm, and I suggested we consider very seriously that we start an energy study we dubbed ARPA-E. I am also currently co-chairing an interacademy study, sustainable energy, the interacademy study represents academies around the world. Currently now the secretary of the environment for the state of Sao Paolo, a major architect in the ethanol for Brazil that is now selling for less than commercial gasoline without any subsidy. It is also important I should point out that that event happened in an environmentally responsible way so that these are really, truly long term sustainable sugar cane plantations. They're not in there for ten years and the soil is depleted. I in my remaining few minutes, I would want to race through the slides, to first have the second slide, I have total control, this is good. I'm the director of Lawrence Berkeley lab which is a national laboratory adjacent to U.C. Berkeley campus. And it -- I don't have total control -- okay. There is a next -- good enough. It's -- okay. Let me -- although this isn't about this, I just wanted to remind us why we're here. There are some dire predictions of climate change that could have very serious consequences, not only for the health of the nation but the health of the world. The probability that these predictions are true, is it a certainty? No. Is it a half to two-thirds to three quarters, we can debate that but the predictions are so serious that if someone told you there is an 80% chance you will die in ten years if you didn't stop smoking you might consider stopping smoking. Whether it's 80%, 90% or 60%, these are the questions. Going to that I think that a dual strategy has to be adopted very aggressively by the United States both to conserve and also to develop new sources of clean energy. On the conservation side,

energy efficiency, the Lawrence Berkeley lab has really led the way starting with the movement of a high energy physicist named Art rosenfeld. He gave up his career in high energy physics to study energy. He turned around the state of California and the United States, to remind you the state of California since the middle 1970s has been held constant in terms of the average amount of electricity used per citizen in California while the rest of the United States went up by 50%. One of the things that rose enfeld was he instituted refrigeration standards. 18 to 22 cubic feet, the standards marked the way of increasing efficiency that now has increased by four and a half times. During that time, the inflation adjusted cost of refrigerators has gone down by more than a factor of two. How much electricity did this save? Well if you look at these bars we would have used close to three billion kilowatts per year and we're using about one quarter of that. That compares to all the conventional hydro in the United States and about a third of the nuclear power which is 20% of all electrical generation. But this is actually misleading. It's better than that. If you consider what is delivered in value to the home, the end user, and you look in terms of money, the dollars saved from just refrigerators, nearly double all of U.S. hydro and is now become comparable to all of U.S. nuclear. Just refrigerators. And so efficiency remains the lowest hanging fruit. This is the stuff we can do best and we should aggressively do this. Now, open the supply side, I want to focus on what we at Berkeley lab think we can do, and it lends to our expertise. And it has to do with harnessing solar energy in various forms. So we've started this program calls Helios which includes several bath ways -- pathways. I'm just talking about two. Plat to cellulose and cellulose to chemical fuels which can replace oil. I'm not going to talk about the management. So the idea here is that in the last several billion years, nature has found a way to convert sunlight, carbon dioxide, to energy. You then release the carbon dioxide. But in principal it can be as good as 95% CO 2 neutral. In a sense that if you include all the energy you need to invest in terms of distribution, growing of crops, what you release in carbon dioxide, it will be at least 90%, probably 95% carbon dioxide neutral. That is the idea. Is there enough land in the world to do this? Because after all we have to feed people. Between 1950 and 1995, the world went from about 2 billion to 6 billion people. Had there not been any agricultural improvements we would have followed that red line but instead we followed the blue line. The amount of land put under agricultural production to increase the feeding the people by a factor of 3 was only 10%. So there are further agricultural things we haven't really worked at all at raising crops to produce energy. And so there now lies within rapidly developing science the ability to transfer a set of genes to make plants self fertilizing, which is very energy intensive to make fertilizer, drought resistant, pest resistant. Once you have those plants how do you convert it into chemical fuels for transportation? Here's an estimate. You can argue by about a factor of two, but let's take a certain plant, Nacansus. The record is 45 dry tons per acre in Nebraska in a field test so we can take 30, be very conservative and take 15. The commercially available today, if you take 100 million acres out of the roughly 400 to 450 million acres that we either have under cultivation or we pay farmers not to plant, that corresponds to 300 billion gallons of ethanol a year, which when compared to the total U.S. gasoline consumption is actually more than that. So, there is the potential for replacing minimally half of the gasoline and all of the gasoline imports with biomass. And I've said you can be very conservative, divide by a factor of 2 and it is still a very excelling number. Where are the biggest gains? Right now the conversion of cellulose material to biofuels is very energy intensive. One can do very much better. There is a new field, synthetic biology, which imports a whole new set of genes. The poster child of this synthetic biology, Jay Kiesling took an active ingredient of a plant, which is a miracle malaria cure, and he has taught E-Coli how to make this plant. It is now going to be distributed to third world countries at a cost of 20 cents a cure. That same technology can be used to engineer organisms to produce other hydrocarbon fuels. There are other technologies where you can use these to have essentially an accelerated directed evolution for the micro and for the genetic plants, mostly for the

mike -- microbes, naturally occur but to engineer them so they will grow suitable biofuels at much more suitable efficiency that we know are possible today and we think by a factor of ten. Let me close that instead of national and international concerns, as we all know, national security ranks very high but national security, again, this button doesn't work, I'll just say it, national security is intimately tied to energy security. There is the economic prosperity of getting out of our dependency on foreign oil, but also, having energy that's affordable, and finally, environmental issues, local and global. Thank you.
>> Thank you very much. Dr. Penzias, you're recognized for five minutes.
>> Thank you for allowing me to speak today. Again, I'll try to shorten this so I'll keep it in five minutes. And then it can be added to the printed stuff I gave you. I bring my testimony in response to the questions that were sent to the witnesses. The first question, what is the current taught of adoption of renewable energy in the United States and what's limiting that rate of adoption? Right now I think it's high cost and elemented supply. High cost and to me, dollars, this is why I'm not -- I have mixed feelings about subsidies. They're all right as an nterim step. But dollars are really the best test of whether something works on not. You don't have to do calculations to know that there is less stuff going into the ethanol in Brazil, it's costing lest. It's a great thing. We don't always want to do that but that's what happens in that case. And I think right now, it's fair to say, that that -- it's that -- that really is the problem. But what's the outlook and what research or innovations could improve that outlook? For me I think the outlook is extraordinarily positive. I've been an alternative energy skeptic for decades. I started in alternative energy some 30 years ago about the same time as that same little hook when the first Arab oil boycott in the 1970s. That's about 30 years. And during that time, the period, I was frustrated by the lack of progress. And not for want of resources. Not for want of will. Not for want of bright people. It just takes time, and the surprises come, in my experience, from other areas. It isn't the people that are looking at alternative energy. The thing I will show you later is made from an automobile headlight. And nobody would have thought that that was going to be a way of cutting the price of silicon, not by five or 7% but by 70%. So that's dramatic. That's the kind of thing that happens when creative people get together. That's what we do in Silicon Valley, wonderfully and this is a -- I'm a zeal of a convert. I work for the largest corporation in the world, and the world's best research laboratory for 37 years. And then when I got out here, one reason I came was, because I knew too many things that didn't work. And boy, have I been surprised since I've been here! So let me move on to some examples of what -- where I think these opportunities are. Silicon was the one I spoke about, silicon, I mentioned and here, by the way, is the automobile headlight. This is a -- this is one piece of a much larger solar concentrator. At the back of it, and we can look at it later, at the back of it, there is a very small, very efficient expensive solar cell. Smaller than the tip of my finger. On an area basis there is no way to use it. For a tiny area you have to pay $6. But because you're able to use this automobile headlight-shaped glass technology, you get a 500 to one improvement. So it looks -- it looks to the sun as if it's 500 times bigger. So it's the private enterprise together with the folks that built this, which by the way was a government laboratory, invented, this triple junction solar cell which by the way is fueling a whole new generation of solar, there is a research company, professional Olnar Wilson, University of California at Merced, who invented nonimaging optics. I was shocked that you could fool mother nature in collecting more light than I would have expected as an astronomer. You can have both broad field of view and enormous magnification, as long as you don't see what's there. The solar cell doesn't care what it sees. It still converts it. This thing by the way has only eight parts. Which is only one more than the 89 cent nail clippers that you can -- than you can buy on a key chain at Walgreen's. $6 here, which works out to be 50 cents a Watt, is the biggest cost. Silicon is four or $5 a Watt if you can get it. A simple example of Silicon Valley. You know about some of the fuel cells, Congressman Honda. We're not talking about details here today. So finally what

should the government do? First and foremost in my judgment, I can't mention that strongly enough, to continue the tradition of supporting our country's research universities. I'm old enough to have benefitted from the Korean war GI bill. That started the whole postwar boom an acceleration which has kept us ahead of the rest of the world. Just as you mentioned Stanford, you could have mentioned Berkeley as well. Everybody wants a Silicon Valley, and it has a great university at its heart. Another thing, the subcities, there is a wide variety of them. I really like variety. Some come from the states, some come from all sorts of places. They spur the man, they get people interested. While some people think that's needless duplication, what it does is encourage exactly the kind of exploration and opportunistic advances that keep our country, essentially the unmatched model for progress in the entire world. I've gone to many countries. Everybody says how do we get our own Silicon Valley, or how do we make ours like the one there? And one size fits all buzz words are great because they lead people into the future. But you don't want to lead people too fast unless you really know where you're going, things like hydrogen economy for example. I think we are -- we ought to be moving past some of those, and I think we are. Now, another thing, there's a vast and diverse needs of the federal government. Those triple junction solar cells were spurred by the high prices of them, they're used for aerospace, defense, other purposes. They're not -- they weren't ready for commercialization but they're available now, since all this stuff from the federal government that comes -- that those needs generate a very important demand. And some of that demand is going for renewable energy, for more efficient lighter weight, lower consumption, even for diverse sources of diesel oil for the U.S. navy through perhaps biodiesel. All sorts of things that are moving this ahead. And then, so it's great that federally funded sales sometimes showcase energetic processes as well. The last thing, the partnering through the federal labs and the private industry, I think, in some cases is very good. One of my companies for example has a very nice Creda, cooperative research and development agreement, with national laboratory, which works wonderfully to get this company jump start sewed that's a nice thing. Finally, you mentioned developing countries. There are opportunities and challenges there. And for me, the opportunities in developing countries, for us to sell to them, we have the intercompany partnering. We can local manufacturing, local distribution, local support. And as unit costs drop, because they can't afford subsidies for that stuff, that will continue. But isn't just colonialism. There's the other side of that. Because other countries have lower levels of infrastructure, it may not be that the central life manufacturing and distribution models, Dr. Chu showed this fantastic big ethanol plant. Cellulose ethanol plant. In other places you may go with something which is more labor intensive and can be done more locally. By example, in a country like India, the southern half, which is -- which is -- has heavy rainfall, would be very good to produce ethanol from sugar cane. You don't need a microbe. You just have local people cut it up because ethanol can be made very quickly from sugar on local areas, transportation costs are saved and there is labor for the farmers who then make their own fuel on the spot. And so there's a lot of opportunity there, the transportation cost is terrible in some of these remote areas. So it helps. In the northern area, you probably would go with Detrofa, one of the species in the Genus Detrofa, an inedible nut which can be squeezed and used directly as biodiesel. You would find on that end the simple calculation shows that a farmer, an unusable acre can give a farmer about $1,000 a year of cash income. You know, third world area for a part time job, just harvesting nuts, hiring somebody in a pickup truck to take them to local little processing plant which doesn't have to be -- bigger than something that could be fit into container. So that kind of thing is wonderful in the third world. Nothing that you would want to use here. But we can explore that technology and folks in India are really moving very fast with it also. You have places like IIT that don't have to worry about understanding them themselves.

>> Dr. Would you please.

>> I represent the electric power research institute, a collaborative research organization, our public and private members account for about 90% of the kilowatt hours sold in the U.S., and we now serve over 1,000 electricity and governmental organizations worldwide in about 40 countries. EPRI appreciates the opportunity to address the prospects for renewable energy and I appreciate the invite. I want to make several key points. The U.S. must keep all of its energy options open to meet the options for future. The integration, utilization of renewables and energy efficiency, as well as building and sustaining a robust portfolio of affordable generations for the future. And that means also the continued use of coal, nuclear and natural gas. EPRI believes that, gating power in a carbon constrained future. Whether decision makers assume the future cost of CO 2 to be zero as it is in the U.S., 30 dollars a ton, $50 a ton, this changes the relative cost of the supply options. A carbon constrained future would make renewable energy more important. Currently renewable generation contributes less than 2% of the nation's electricity supply. Until recently, based on approximate projections from the not been significant. Long term estimates for contribution for renewables to the total electric energy remains around 2%. Recently some new EPRI modeling shows that renewables could be expected to increase substantially. In one base case scenario in an EPRI model the estimates showed the contribution for renewables by 2050 in the range of 5 to 6%. Now this represents 700 to 800% increase over today's megawatt hours. And this would be noted that this does not take into account the introduction of a disrupted technology which would significantly decrease the cost of these renewables. Various distributed generation technologies which include renewable energy sources such as rooftop solar are being developed and they with will enhance the current distribution system. These will add power system flexibility, increase end use efficiency, distributed generation and central station generation are not either/or alternatives. EPRI believes they will have to compliment each other in the future power distribution system. There needs to be, ocean energies are not dispatchable i.e. controllable resources and that there will be a cost associated with the integration of these resources into the system. The cost is small today when the significant portion of the available generation such as nuclear hydro or gas turbines is dispatchable. However as the percentage of renewable energy increases so will be the cost to grid generation. Meet the electricity demand in new and better ways. Economic roof toll solar, clean fuels from biomass, will help diversify, in summary, given the expected growth in demand for electricity and the many uncertainties in our energy future, we believe that developing diversity in electric generation is critical, as an objective for the country. Also striving for cleaner and more sustainable resources will bring more renewable energy into the mix and future break throughs in cleaner fuels will change the nature of the electric grid. These will not replace the need for the electric grid but they will increase the flexibility and value to the country. Thank you for the opportunity to speak to the committee..
>> thank you very much. Mr. Pearce you're recognized for five minutes.
>> Thank you for the opportunity to present here today. Madam chair, did you get the name correct, Miasolé which loosely translates into into my son. I'm here to talk about solar energy. Just a quick overview on Miasolé. We are a Santa Clara based California manufacturerrer of thin film solar cells. A bit unique in that we're trying to bring manufacturing jobs back to Silicon Valley with an 80,000 square foot facility. We expect to be in volume production later this year. Myself and my team have a very long history of high volume, thin film component manufacturing going back to the '80s where we made hard disk drives for data storage applications, more recently optical components for fiberoptic communications and now taking the same core technology to introduce thin film solar cells. We're backed by several leading venture capitalists, the most significant of which are Cliner Perkins and venture partners. A little background on the solar industry. The industry is experiencing a 43% compounded growth rate for the last five years. So it's caught a lot of attention of the investment community. And it's certainly making

great strides. There is increasing adoption worldwide of incentives and subsidies to support the growth of the solar industry. Just last week, the country of France introduced some major incentives, very close to those being implemented right now by Germany. And certainly the state of California leads in the U.S. in terms of the size of its photoelectric program. The very high demand, though, for solar has created shortages for one of the key feed stocks. The basic silicon material that is used to make the dominant form of solar cells which is based on crystalline solar technology. It represents 90% of the market. We believe at Miasolé as do many of our competitive startups that there is an emerging class of thin films that hold tremendous potential to directly lower the cost of solar. In particular, the thin film technology allows the technology of building flexible solar sells, flexible modules, opens up the opportunity for attack the entire value chain. Miasolé's thin film technology we believe will be capable of supporting a 60 to 70% reduction in the price of solar. And generating a reasonable profit margin for the company in the process. At that point, solar is competitive with grid generated electricity from conventional sources in the range of eight to 10 cents a kilowatt-hour. And we believe this goal will be reached well within the time frame of the U.S. Department of Energy solar American initiative which has set a goal to achieve price parity by 2015. And I mentioned, we're not alone. We have several very strong venture backed entrepreneurial companies that have also entered this market. We think the entire industry is on the cusp of some major changes and it's exciting to see the investment coming in, it's exciting to see the attraction of very senior management teams that bring with them a breadth of manufacturing and high-volume experience. So I think the stage is very much ripe for some disruptive change. So to speak a minute now about thin films. Thin films represent a class of semiconductor material that, by its very name, it's very thin film of approximately 1/100ths of a thin film. It is a continuous deposition process. We take a meter wide coil of steel two miles in length and continually coat a thin film on it. We are building one of these roll coaters in Santa Clara and expect to populate our factory by the end of 2007. If we achieve that goal, it will make Miasolé the largest producer of thin films in the world. Laboratory facilities for material we're working with, the acronym is SIGS, for the element in the semiconductor, very high efficiency, 19.5% achieved in the government labs, very close of that of polycrystal and silicon. While the laboratories have done tremendous research work, it hasn't really translated a significant way into the commercial marketplace. What the commercial market has lacked is high volume manufacturing technology. And that's what's starting to happen with companies like Miasolé and some of our competitors. We're all taking slightly different angles and trying to leverage other industries to what's been proven in the government labs. And that is a tremendous stepping-stone to have all that fundamental research kind of behind us. The flexible solar cell in our case, on this very thin stainless foil, allows for flexible modules, again, easy to install, lower the cost throughout this value chain. And I think the most important thing that is going to happen to solar over the next five years is, we're going to see a major move to true building integrated photovoltaics where PV becomes ubiquitous with the installation of a new roof or a new commercial building. By now, the vast majority of the market is retrofit and we need a paradigm shift there. Next slide, what can Congress do to help? I think big steps are being made. There is currently outsourced solicitation, the solar America initiative which is virtually a doubling of funding for solar research to about $148 million a year. A major portion of that would be granted to the most promising private companies to accelerate research activities. I believe there's an opportunity with the Department of Energy's building program. This is a program that, to a large extent, is focused on efficiency, and zero energy homes, with a goal of achieving by 2020, a zero energy new residential construction. Well, with the shift in population in the U.S. to the south, the west, and the desert southwest, we have tremendous new residential developments. I vested one just a month ago in Albuquerque that is proposing 37,000 new homes. That's a tremendous opportunity to put solar on every one of those roofs. And if we miss that

opportunity, it's 20 years before we get another shot at it. Because that roof is not going to be replaced for 20 years. So I think maybe a closer look at the building program, and how we could marry that up closer with the solar American initiative. Last year, the energy bill included a provision for 30% investment tax credits for solar installations. It was capped at $2,000 for residential. First, it's a very impressive that we got that level of investment tax credit through. But I'd like to see it extended through 2015, as presently proposed, and also, an expansion of the residential credit. Because at $2,000, it's insufficient to cover the typical electrical needs of a residential home. And finally at the commercial building level, I think there's opportunities for a federal loan guarantee program. We have such facilities for large power plants, but if we could downsize that, and make it available to commercial buildings for large scale distributed solar generation I think there is a significant opportunity. Right now, as a business owner, and I look at opportunities to spend my capital budget, I, like most of my brethren, look at two or three-year pay backs. You just can't get that with solar because you're really buying an asset that generates free electricity for 25 years. So if there was some financial facility that made it possible for the commercial building owner, be it the big box retailer or the big warehouse to put solar on in a mechanism to kind of get that off their balance sheet so they could justify the financial investment, I think that would go a long way to making commercial installations much bigger. Thank you.
>> Thank you very much. Mr. Swenson.
>> Thank you very much. I appreciate the opportunity to speak today about international renewable energy education and I especially appreciate the thoughtful questions that were raised by yourselves and your staff. It's appropriate that we're holding this meeting in California, since the 49ers gold rush mystique spread far and wide, California has changed the world several times. Hollywood and Silicon Valley symbolize those changes. Now, Silicon Valley is rising to a new challenge to save the world from global warming produced by carbon energy to global sustainable produced by silicon energy. Since 1992 I have been involved in renewable energy education projects primarily applications of solar panels, in Mexico, South Africa Ecuador, and other countries. In Quito, Ecuador, announced, energy applications laboratory, in the Galapagos islands. We call this the Real lab by the acronym. Since 2002 we have been providing human capacity building, that is to say training with young people and the staff of the electric utility there in renewable energy, installing wireless Internet first of all, then assessing energy conservation for the community, monitoring the performance of the solar and the diesel -- generators which were there before we arrived. We call what we do productivity service learning, learning by doing, in simpler terms. We are integrating these international initiatives to transform energy on the islands to renewables in order to reduce the risk of oil spills that would threaten the unique and endemic wildlife there. With guidance from the UNVP, Ecuador's ministry of energy, each university here in the state brings unique skill sets to bear on renewable increase research and renewable energy education, and they will, in turn, partner with universities in Equador and other nations will also enjoy these relationships. There are some differences, in developing countries, the market is eager, but capital is more scarce. In remote parts of the world modern skills are lacking and you can't just jump from the three Rs immediately to science and physics. Another thing is that fossil fuel subsidies penalize the economics of renewable energy as it does here, same as it does there. The electricity cost twice as much to produce from diesel there. According to the international energy agency energy subsidies add up to about $200 billion worldwide each year. What if we were to invest that money to build lasting solutions instead of propping up the fossil fuel infrastructure which is failing us? You've also asked how we structure our renewable energy education program. I've already hinted at it but to say a little bit more, just the same the way that apple computer developed a loyal following by supporting computers in schools, so we are matching up universities in the U.S. with universities in the real lab countries. Taking this one step further, consider what it might be like if

we looked at the 100,000 schools in Latin America still have no electricity. The U.S. government could sponsor solar systems could be installed in every one of these schools. Even $100 million for a small solar system on each of these impoverished schools would be a huge improvement. A government energy partnership would bring huge benefit to our U.S. economy and our political welfare. Renewable increase has the advantage of being bite sized ubiquitous and grid interdependent. Grown as resources become available. Coal or nuclear power requires a huge investment but one's family or village can start with solar on a very modest scale. For example, we installed a 2 kilowatt system in a village in Bolivia, only four watts per capita, less than a night light per capita and yet it made a huge difference in that community. The political and economic implications for renewable energy in the national arena are enormous. Renewables are carbon neutral and they are nuclear free. The threats of developing nations from nuclear based energy are as foreboding as climate change. The day may come when all national regimes are stable enough to control nuclear grade materials but humanity has not mastered this yet. Justify the nuclear alternative and they get persistent encouragement from the ambitious nuclear power industry and if not from the United States then from Russia, France or others. If the U.S. and its responsible G-8 partners were to offer these nations a large scale and lasting renewable energy solution the energy deficiency argument would fall apart and the world would be a far better place. Renewable energy is the answer. Repower the Galapagos through renewables. Through education we are exploring bridges of understanding packaged with U.S. energy solutions. So imagine the $100 million scholarship fund from national science foundation. We would create partners in develop, not just consumer markets. Renewable energies are mature. Coal and nuclear may be made as a last resort but they are at best a, the sun is developing 100,000 terawatts. I would invite you to join us in the galapagos islands, and I would say further that if people want to look at the tale of some of my comments you can go to siliconenergy.org where I posted some other remarks.
>> Thank you very much. Maybe we can organize a science trip to go and see what you're doing down there.
>> I'm there.
>> Love to have you.
>> Madam chair you may want to also notify the audience and our witnesses that we have a very tight schedule. And we need to leave at 2:30 sharp.
>> I will. We'll proceed now with the questions and we will each take five minutes and then rotate. So if we can have short questions and short answers. Maybe that would help to get through all that we have. This past year we had a -- there was a demonstration on the mall in Washington, of solar houses that were built under a competition from DOE and sponsored by numerous corporations. And the university students participated, and they came up and put up 850 foot houses and put them all together to demonstrate how you could have an all solar-powered house. Now, they happened to pick a week in Washington that it rained, the whole week. Absolutely the whole week. Now, that reminded me, and I live outside of Chicago, in the winter time particularly in January and February, we seem to go for weeks and weeks without ever seeing the sun. Being here, the beautiful California all the time, is there -- is it practical to use solar energy in the higher latitudes with more diverse climates like in Chicago, or where you have a lot of rain? I'd like to ask Mr. Pearce.
>> Yes. The world's biggest market for solar is Germany, that was 57% of all installations last year, worldwide. And they have a climate that is -- is bad if not worse than Chicago. So even in the rain, solar systems are going to be producing electricity. So obviously it is not going to be as much if the sun's shining brightly. But definitely a major opportunity.
>> Thank you. Then Mr. Larsen, you see that ERIE -- EPRI I'm sorry, EPRI has different outlook for the

market than the energy administration. Talked about how important assumptions are to the modeling results. Why do your -- why do you think your models and those assumptions differ from EIA?
>> I believe part of the answer is that, well, the basis for the model that we created was the NEMS model. So we took the output from that model and then introduced regional differences, other economic inputs into our model to try and shape a -- an output for a 2050 outcome. So really, we took in regional differences, across the country, across the states, to really start drilling down into what was different with various -- what was different with various RPS inputs and assumptions as well as various assumptions on the cost of electricity. And again, there was no assumption on a dramatic change in the technology or any disruptive input that would significantly reduce that cost.
>> Do you see anything adding to that, with the change technology that we seem to be moving forward on so many of these things that we haven't in the past?
>> Oh, absolutely. It's a -- for us, when we create a model, it's difficult for us to take a good snapshot, since oftentimes the technology's moving so quickly, as it is today. The model that we generated was based on 2005 data, and that -- I mean six months ago, that's a long time ago, with respect to what's happening in the industry and what we're seeing in the valley today, with respect to solar technology development.
>> Well, if we say an oversupply of only 1 to 2% of the oil demand, if sustained, can cause prices to drop dramatically like in the late 1990s, what happens to all of those renewable energy investments if the Price of conventional energy drops in two or three years, whether or not this is a deliberate OPEC tactic? And we'd like to answer that Dr. --
>> Yeah, I could speak to that. Here, go ahead.
>> You both can.
>> Okay. The simple answer is price. The price of coal is a price in human lives. In railroads, you can't just drop the price of coal. And coal is what generates our -- the electricity in this country. There isn't -- natural gas is not controlled by -- so if we talk about electricity only, then there is -- that isn't the problem. But the issue is still price. And a dramatic change in the cost of electricity generation will make a huge difference. So I think it's beyond, on that side. On on the petroleum side, I think it's essentially independent of demand because there's almost no petroleum used to generate electricity, that's to my -- if I remember from the chart. Thank you.
>> Mr. Swenson.
>> Yes, the largest oil field in Mexico, Canterel, is on the verge of dropping dramatically, to within a quarter of what it was doing before, within the next couple of years. The north sea is declining. I believe there could easily be a reversal, where the price of oil could go down for a shortly period of time. But we are seeing an inexorable change in the price of oil. It is hit not only with regard to price. We are getting close to the time when the rubber band is stretched tight. While there maybe some temporary reversals, the trend is distinctively for higher prices in oil.
>> Dr. Chu.
>> Going specifically to your question, we have an example in Europe, Danes were successful in encouraging wind power development. The way they were able do that is they would guarantee that some return on investment, so they would stabilize things. So just in case the bottom does drop out, they would have a floor that said, okay, you can make a certain amount of money. A similar thing has to be done. If and when we go to the carbon trade, if the price of carbon goes too far down it would snuff out a lot of investments. And so there should be concern about a minimum floor. Otherwise, because many of the things that you heard are, you're talking about a 3, 5, even 10 year investment. So you have to be very conscious about guaranteeing a certain investment over a stable period of time.

>> Thank you. I think that's what concerns me. I think we really have to move ahead and we have to in all kinds of renewable technology right now, we really have the opportunity to do it because people are concerned about not having enough of the conventional fuels that we have, and we have to move ahead, you know, the long-term to nuclear, long-term to ethanol and all those things in between. And solar can be an in-between. But all the development that needs to take place, we need to move now, so people understand it is a process that takes a while. Mr. Honda.
>> Thank you, madam chair. Before I start my question, I'd like to recognize four gentlemen up there in the red tee shirts, the Santa Clara university solar decathalon team and we want to welcome you. [applause] It's not only solar energy we tap into, it is the youth energy we tap into also. Welcome, it's a pleasure for you to be here. Could you discuss grid renewables, to integrate as the percentage of the numbers of renewables goes up? I think I heard you say that and I was curious about what you were thinking.
>> Yes, Mr. Honda, the issue with renewables and the state of the technology today is one related to dispatching and controlling that resource. So for instance, we have wind, or solar, which the wind blows, certain times of day, the sun is out certain times of day, and we still have not fundamentally solved the bulk or large energy or electricity storage challenge from a technology standpoint. So for instance, if you look at the peak -- the peak coincidence, so the peak load versus the peak demand, if you compare demand versus what we're dispatching with wind, the peak coincidence is probably in the single digit percentage points. So when we have peak demand during our hot days or hot demands such as we did in the state a week or two ago, the wind may not be blowing at all times for us to be able to dispatch that wind power to support that demand. So that presents a significant integration challenge to the grid. So if we don't have -- if we're relying solely on a noncontrollable resource then we're going to have to get that energy somewhere else. And with today's take it, that would come from in the state of California, most likely natural gas or combustion turbines. Where other dispatchable assets that we can turn on and off. The other issue with respect to wind are just the ramp rates, that we are seeing when the wind does blow and when we are able to dispatch that energy. The ranch rates or the increase from zero to 100% on a lot of these wind farms is significant and produces a significant challenge to the grid. Where we are today with 2% across the country or less than 2% of renewables as a part of our generating portfolio, we have the capacity to make up for a situation where we can't dispatch wind or if we don't have that resource available. If that percentage increases, significantly, then we will have to either achieve that gap or close that gap that we're going to have by end-use efficiency or other storage means in order to make up that lost demand or the demand that we can't meet. So as --
>> So it's really a juggling of the difference sources, and I guess in terms of what you can control immediately would be your grid?
>>> Absolutely.
>> That sounds like the backup, so your peaks would reverse, probably, in terms of management?
>> Yes.
>> Well, most of the grid decisions are made -- we don't transfer our electricity really very far distances. If you look at how it's generated and how it's used, there is research being done on very high voltage DC transmission. The cost of DC transmission is high, a million dollars a mile. Once you can think about transmitting electricity over 2,000 mimes, a lot of the issues you just heard about are greatly diminished. One of the things, renewables, it blows somewhere in the United States quite often. Once you have relative reasonable transmission, this is something that is rarely discussed.
>> The Northeast blackout shows the way the present grid transmits energy from one place to another is that everything has to stay 60 cycles. And that, when something gets a little out of whack and one cycle is

going up and the other one goes down, all of a sudden the Northeast of the United States becomes the darkest spot on the planet. So the possible -- a national security issues could be to separate the -- to separate pieces of the grid, even if you don't, you get the DC across the country. If you just put D.C., if you connect areas, if you see all D.C. connect, A.C. connect to others, perhaps folks at EPRI could talk about that. We don't stabilize the present grid because of private enterprise, they can't afford it. You folks may look into the possibility of making our grid more secure, and then also, when it's more secure that also allows it to -- if it could respond to the loss of energy in some way, it can also respond to the loss from renewables. You get both at the same time, national security and in robustness this way as well. That's another possibility.
>> Thank you. Thank you. Mr. Pearce, you said that the government labs did good fundamental research but that the problem has been scaling it up to manufacturing scale. Do you think that D.O.E. could work differently to address these areas and because D.O.E. doesn't focus on this, how does the industry leader look at D.O.E., Department of Energy as compared to looking at internal labs or universities?
>>> Well, I think D.O.E. is starting to make some changes No. in the last few weeks there was a new major laboratory opened at national renewable energy lab. Specifically designed for manufacturers to bring in their equipment, place it in the facility and operate it there through ENRAIL personnel. Miasolé intends to put personnel in that facility for high end manufacturing capability. I think the D.O.E. and particularly the end rail program is absolutely on the right track to make that happen.
>> Mr. Pearce, on a personal basis, taking personal privilege, I'm thinking of working and doing my whole roof over again, you better do it when you do that. How does thin film photovoltaics, in terms of available, long temp efficiency, energy output so on?
>> Right now, most of the thin films are less efficient than the crystalline silicon. The thin films are reported to do better in low-light conditions, early in the morning, late in the evening. So some of that washes out. In most applications, you're not constrained by the amount of roof space. In fact and area of about 400 square feet, about the size of a two-car garage roof would be adequate to power the needs of most residential applications. Even at 10% efficiency. I myself, holding out for Miasolé solar panels on my roof. I hope you can hold out, also.
>> Well, I need my roof before the rainy season. And this is not the gulf states. So Dr. Chu, the Helios project is a dramatic example of technological advances. It may help to have a time understanding of disruptive technologies. Do you have an idea what that is, five, ten, 15 years?
>>> Well, we're hoping for something on the scale of ten years. If you think of -- look at the Brazil experience of how it had to scale up its ethanol production using existing technology, it still took more than a decade. So I think one would think that right now, Motown of our ethanol production in the United States is via corn. Although in the long run that is not sensible it can be used as a means of transitioning. You get all that infrastructure going, in the meantime, you develop very aggressively better plants to be raised and better means of converting that feed stock, biofeed stock into fuel which, ethanol again is only a temporary stop measure. Dupont and BP are partners, Butanol is much more desirable than ethanol. But you get it going. When it becomes a 20, 30, 50% replacement for gasoline, this is a scale that will take literally a decade, decade and and a half. Even when it's aggressively pushed. When it's not aggressivelily pushed, it will take much longer.
>> I hear the concern about other countries graduating 300,000 engineers and scientists and things like that. My sense is that they're not all in the area of technology that we're discussing right now, probably more in the infrastructure science for those developing countries. But the way I think that we can stay ahead is the way we teach. And looking at those who are creative and innovative in all the countries, you look at their employees, a handful have, if you did a bash thing, you'd see maybe a handful of engineers

and scientists having a handful of patents and the rest are less. Looking at these folks and trying to understand how they think and how they perceive things, my question to you is, do you think that it's possible to look at these individuals and extract from them the skill sets to be able to do that, and teach those skill sets from prekindergarten to postgraduate, start with Mr. Swenson if you don't mind.
>> Are you saying here in the United States or are you thinking in terms of the international or both?
>> Whomever we would identify as, you know, in terms of looking at those skill sets.
>> Well, in the developing world, the people have maybe the ability to do basic reading, and they have hand me down texts and so forth. So there's a huge gap to raise up to the level where you have the background in math and so forth to be able to start getting into science and technology. There are others here who could speak more -- more effectively to the domestic circumstance. But I think that as I said earlier, if there were some opportunity for the U.S. to encourage education in other countries, and to bring people here, sense people there, that what would happen for the students here in this country is, they would be stimulated, because you learn by teaching and you learn by doing. I think that could make a big difference.
>> I'll come back to that question again. And the chair would like to go through another round.
>> Thank you. Mr. Swenson, do you think it's possible that some developing nations will just leapfrog the U.S. and other developed countries in using fossil fuels and go straight to economies based on renewable energy? If they could do that, why do we see, you know, China and India turning to fossil fuels and really having such a need for those?
>> Well, I hope that we can turn that situation around very quickly. I think that the debate is pretty well over about whether the use of coal is creating a hazard that is untenable. And so to the extent that we can set an example here in this country by doing an about-face, and ramping up in a big way our renewable technology, that will become possible in other countries. And our experience is that these technologies usually are embraced and when you consider that there's about 2 billion people who have no electricity at all, and the rural environments in which they live are very hard to provide infrastructure, I think that a small amount of solar could be a huge benefit. And as I mentioned it's ubiquitous, it can be put anywhere on the face of the earth and you're ready to go. So I think that it mate be true that China is heading in that direction and India to some extent, my hope is that their political leadership will join with us in recognizing that we have to start protecting our atmosphere and ramp this up. And I guess the other question is can renewables be ramped up? My answer is very distinctly yes. It has to be ramped up to my way of thinking somewhere around 50% a year. We did that in the dot-com area and growth rates were enormous. I think we can do the same thing, particularly with thin film PV as Mr. Pearce has suggested.
>> Well we certainly, I think we're a very competitive countries, when Japan moved ahead with the largest computer, the earth similarity, I think is it Monte Vista that -- Microsoft, who brought it back, we don't want anybody get ahead of us in renewable energy either. I'd like to go back to wind for just a moment. Illinois has put on hold the wind, that will affect the air flight over that area. Has California had any problem with that, having to change pattern or is it a ruse in Illinois?
>> I'll try first with the answer. I'm not aware of any issues like that in the state of California. I do think that there were issues or concerns about avian migration paths. But I'm not aware of that issue in the state of California.
>> I had a discussion with John Rowe he said the regulatory committees wouldn't allow him to put in a raise in rates for the huge windmill farms. They see themselves as consumer advocates.
>> I must say, I have an article that was written in May about rooftop turbines putting on City Hall in Chicago to generate wind power. And they say that the -- the already installed was one on top of a hill in a museum courtyard in San Francisco, one in Chicago suburb, and one in Troy, Wisconsin. I haven't

heard much about them but they say that safety was the big issue. Aerotech customer representative said, the most important is to make sure the turbines don't come loose and fall off. I wondered if you'd heard anything about those turbines. I haven't seen anything in the city so I don't think it's there yet. While we're introducing people I would like to note that Dr. Percy Drell is a director of research at the Stanford linear accelerators here, the group from flag. We'd like to welcome all of you. Thank you. Mr. Pearce mentioned some very specific policy options including incremental funding for building integrated solar third party financing. If we had $10 billion to spend on these kind of policies, and I don't mean to imply that we do, I'm only an authorizor, not an appropriator, how do you think we should authorize the spending of the options, what are we likely to get the most for our investment and why, maybe we could get the most of those, start with you Dr. Chu.
>> That's actually a tough one. Because I mean, you for example heard today discussions about solar. There were -- there were three approaches to solar. And so I will go back on a basic philosophy, I and many others advocate, is don't really pick winners. But adjust the boundary conditions to spur the investment of industry. So I'll go back to the you know, have a guaranteed stabilization of what long term investments will be. And again, it comes back to starting to put in the real cost of emitting carbon. And once you do something like that, then all sorts of things will tilt. The industry coupled with science and national labs all the rest will develop winners and they'll find their way.
>> Good answer. Thank you Doctor.
>> Thank you. Again, I would echo, what Steve Chu said. And again, with the idea of creating a climate rather than picking any one thing. And so a climate in which it is possible to put wind power in place. Wind power, to answer your earlier question, is most effective, the larger the windmill becomes. And so right now, the biggest windmills, the rotor on a huge windmill is now getting to be the size of a football field for a single medicine. But this is probably the best solar energy that your state can get, because after all, wind is a way of converting solar energy into mechanical energy and so you're there. So it's that general tax climate, not subsidies but encouragement so we level this playing field in things like these other alternatives. It isn't just solar. There are a number of others. But again, and please, and please continue your fine efforts in this direction. Thank you.
>> Mr. Larsen.
>> We at EPRI firmly believe in investment in R&D. We also firmly believe that we need to work to keep our options open. There are uncertainties in both the cost of the various fuels. There is uncertainty for the electricity industry today in carbon legislation. So keeping technology options open, to generate economic power, is important. So picking a winner would -- might constrain us or limit our ability to address an alternative future. That having been said, I think there's obviously investments that need to be made into the alternate technologies. A lot of these do change the makeup and the operation of the systems.
>> Thank you. Mr. Pearce.
>> Well, I would say ultimately, the funding will come out of private enterprise, that the government programs there should be to stimulate the market conditions, to stimulate the early research. But there's nothing that's going to compare to the success of a very healthy alternative energy market as far as generating research dollars from private industry.
>> Thank you. Mr. Swenson.
>> Well, as I travel through the developing countries, I bump into Germans all the time. And then I was doing a project here in Salinas, a solar project. And one of the American companies told me, well, we have to consult our engineers in Germany to figure out how to do this, because I presented them with a tough issue. So I think that what that shows you is that the subsidizing, I know that Dr. Penzias is objecting to subsidies. But the fact of the matter is, around the world we have huge subsidies. In Egypt

the subsidies is practically given away. In Venezuela the gasoline is practically given away. So when you compare these existing conditions and then see what one country has done with lousy solar resource, to foment the market, it wasn't the cost of putting the electricity together for Germany, what matters is they have a high ground now in Germany, now they have the expertise to go around and they have companies in the United States, they're treating the United States as a third world country because we don't have the expertise that they do anymore. It is incredible how quickly it happens. Mr. Pearce and his colleagues in the power of thin film, if we gave them a boost, it would be a chance to recapture that lead. But the Germans are offering him and his people in the same business huge opportunities, discounts and free space and here, come to our place and we'll put up a factory for you, and you know, give you five years free rent, no taxes. And we're just not doing that. So -- so I think that the opportunity here exists. If we cover our domestic needs, we will begin to have the ability to export again.
>> Thank you very much. Point well taken. Mr. Honda.
>> Thank you, Madam Chair. The idea no area of the country felt the impact of a the dot-com boom and the bust more than Silicon Valley, and there's a similar market frenzy developing around renewables especially ethanol, how do lessons learned in the dot-com era apply to energy tech and are we heading down that path already, and if we are how do we avoid this phenomenon that we have experienced at that time?
>> I think the two ways, two things avoiding it. One is again this idea of not picking winners. I think in the dot-com bubble, there was a focus on certain things like consumer behavior, which didn't happen. In number of other cases, the -- what was called the deregulation of telephone companies was going to change the world and all kinds of stuff like that. So here, we have a huge market. Which is not going to go away. There is a huge market, in energy. It almost -- the sun never shines in Denmark, and they're getting 20% of their electricity today from solar, in the form of wind. And the solar that they're putting in today is the medicines which are being put into this, I spoke about these football fields, they're getting bigger than that. The technology as something as old fashioned as the windmill has gone in an unbelievable pace in ten years. Look at the dead stuff in Altamont pass, it doesn't work. But this huge change in technology has made this happen. So I see this power of technology, plus the huge need for energy. I don't think the people in China are waiting for a cue from the United States. They desperately understand, they can't breathe in Beijing. Sometimes their factories are turned off, they don't have enough electricity. They would use solar if it worked, it will work but not yet. That's where we're going. Stay tuned on solar. Number of other areas. There are enormous opportunities also in conservation which we didn't mention. I can speak to some of those later, fuel cells, there are a great number of others. We happen to be highlighting solar today. This story, march of technology, coming through American creativeness and diversity. Oh, yes, in one of my solar companies we do partner with a German printer. But the innovation is still in the United States and I think we're moving there. And the only -- and I think we're doing a lot of the right things and we will learn from mistakes.
>> Okay, thank you, Dr. Chu.
>> I think if you over, subsidize, you can do a real danger, just as if you don't. Subsidy in either form, you tax the coal, to give long term stability and encouragement. But where a plan is in sight. So take in wind in California in Altamont pass, the first time in the '70s and '80s, it was in my opinion oversubsidized. Inappropriate technology was stuck up there, because you're going to get money even if you stick up something that doesn't work. So Denmark did it right in the long term and then that sustained -- the technological improvement that's leading to these huge windmills that are extraordinarily efficient, so I think it is a very good question, is you can't just legislate a huge subsidy because that will end up in a boom-bust.

>> I can speak to this a little bit further. Because of the subsidies that are now in place, that we have already picked ethanol as a winner. And truth be known, it has, because of the way it's produced, it has high carbon content, that is to say, that the power plants that run the mills use coal. That a lot of natural gas is used in the heating process. And so it's pretty much 80 to 90% ethanol -- 80 to 90% of ethanol is fossil fuels the way it's currently being fabricated. So I think therein lies a danger. And if we look at the example of Brazil, the truth be known there, only if this were happening in the United States, it would be equal to about 4% of the energy that we use here. Because they use vehicles about 10% as much as we do. Their transportation per capita is about 10%. So these lessons don't necessarily translate just by multiplying their success with ours. Because our circumstances are very different.
>> Right.
>> And so I'm quite concerned about the the over emphasis on ethanol. If you took every square foot of paved land in the United States you could produce five times as much as you could from all of the cultivated lands of the United States which, after all, have something to do with our being able to eat. So we have to balance food with fuel.
>> Thank you. Let me get back to that question of innovation and teach innovation. If you have -- unless Mr. Larsen you have another comment to that last question.
>> Just a quick comment on the pitfalls of the boom and bust and avoiding the, I guess, avoiding making past mistakes. I think the -- we need to keep the options open. But we also need to focus on the cost of generating this electricity on a cents per kilowatt-hour in comparison to where we are today and also in the future with the potential impact of carbon legislation and to keep that in mind in evaluating all renewable technologies as we're moving forward with the goal in mind to develop technology that is cost effective and economic and competitive with -- with other technologies as a part of the portfolio.
>> Okay.
>> With respect to your question on education, I think Miasolé's experience is pretty typical here of Silicon Valley. We have 58 people, a significant portion of those are engineers and scientists, and I would guess 40 to 50% of them were born in some other country and trained here in the U.S. I think the whole education issue really goes back to middle school. We have to get more boys and girls interested in science and math, because if we lose them there, we lose them in high school, and they don't go on to engineering programs.
>> What I was driving at is, taking the phenomenon of being innovate and creative, that's -- innovative and creative, and embodied in a person who is creative and innovative, and being able to extract that. What is that about that person that is creative and innovative, to teach those skills to children and from preschool to postgraduate? The idea of being able to teach that skill, so that it doesn't matter where they go to science or math, that they have different insights and different ways of looking at things, whether they go to music or to performing arts or to social studies, that it's a different way of thinking and looking. And I was just curious whether you thought that those are teachable -- that's possible, number one, and number two, teachable?
>> Well, I think that is possible. And I think in fact the U.S. does a pretty good job our area. I mean, particularly our institutions on higher learning. We generate a lot of people that are, you know, creative, and you don't get that to the same extent in other countries.
>> But is it a conscious process, teaching innovation and creativity?
>> In our case in the galapagos islands, we gave students to measure the performance of the refrigerators in their homes. And one student showed his electricity bill next to the graph that showed the performance of their refrigerator, next to each other, they were quickly galvanized and motivated because one kid had -- their family had twice the electricity bill as the other. And that was like 10% of their income

in the -- you know, living a different lifestyle than we have. It was a lot of money to them. And so there was motivation. And I think that service learning which is productive, so I go back to that term productivity centered service learning, that galvanizes young people into being aware that they can make an impact on their community. The ministry of energy came from the mainland and interviewed our students because they had a program that wasn't working. They wanted to see how our kids did it. And it all had to do with the fact that we gave them something productive, something meaningful in their community to work on.
>> Yes, Mr. Penzias.
>> I have two ways for innovation, one of which works well here in the United States very well, I think, which is diversity. I wasn't born in the United States. A lot of other people weren't. But I think the fact that having a mix of ages, I mean one of the nice things about Silicon Valley is, it's not youth oriented, it's age agnostic. Many of the CEOs I work with could date my granddaughter, and nobody would care, because it's age agnostic, race agnostic, age agnostic, ethnicity agnostic. I'm sorry ton a grouchy old guy in this. I think we have to get the school out of the way of undermining creativity. I'm blessed with 12 grandchildren. They drive you nuts with their questions until they get to school and learn to stop asking so many. We are -- and it's a very simple thing to -- we really ought to encourage teachers. We are I think the only country in the world that spends more money on bureaucrats in the education budget than the people actually going to the classroom. [applause]
>> And then, we decide okay, let's put in -- and let's fix that by putting in a testing program which gets yet another level of conformity. So -- [applause]
>> So get -- so we could somehow get all these folks out of the way of teachers. I think by itself, there will be a -- it would make a difference. And the better teachers, and in fact one of the things we've learned is of course, and I've seen studies on this, the classes that -- any school, where this intercity, large, rural, urban, better teachers make for better kids. So I don't think we have to impose anything on them. I think we need to get rid of this upper structure. Now if you are talking about taxes, maybe you could put a tax open bureaucrats -- anybody -- educational -- not tax but stop encouraging, stop subsidizing these -- the administrators and put the money into the classroom and out of that. Change that balance to where it is in other countries.
>> All right. [laughter] I know Dr. Chu's family is full of innovative creative thinkers. What goes on in there?
>> Well, I was born into a family, me and my siblings always questioned authority. But in sort of taking where Arno Penzias left off, the United States in higher education does it better than other countries. But I agree with him when you look at kids, before school they're full of curiosity. But schools are more effective of stamping out this natural curiosity. The greatest thing about the United States school system, I get asked this all the time, why doesn't China have home grown Nobel Prize winners? I think because teachers in those countries aren't questioned by their students. It's considered disrespectful. They're punished for it. But you can question your teacher in a very respectful way and that's the way it should be. So -- so the United States is actually quite good at it. And then I think about what is it that we have done better, in science, it actually goes back to when we were in first, second, third grade when we were asked to give book reports. And it was a different thing. What did you -- what do you think about what you just read? Very different than in -- in many European countries and certainly Asian countries. You're not asked what you think about this. So we have to encourage more of that.
>> Would you like to say a few words in closing, perhaps?
>> This list here if I want to make a comment, I'll find my notes.
>> Let me just say we could spend a whole hearing talking about education in the science field. And I

agree with you. I go out to the schools and particularly middle school and I find particularly the young girls, boys do math and science, girls don't, and that's a real shame. Try to encourage them, this is a field wide open to them.
>> Thank you Madam Chair. The blue ribbon task force on nanotechnology, the Cerrie yang, Dr. Bell Wade from San Jose State, Vern Beecham. Our selection committee, Norm Woo, Dan Mederly and Chris Moyland. I want them to be recognized in making Silicon Valley the great place it is. I would close with this thought, that the federal government has been a major player in innovation and technology, and moving technology forward. I guess my question, in terms of -- and the thoughts I want to leave with people is that we still have to impact more people, and individuals and citizens and consumers, if you will, and I guess we might want to also look at what is a role of city government and county government in changing some of our attitudes and creating some demands on alternative energy because cities and counties and states, if you will, also bear the brunt of that burden, in many different ways. And so I would beseech all of us to start thinking about another way of approaching moving this agenda forward in terms of promoting alternative energy and having us think outside the box in a new paradigm, and to the witnesses, personally, thank you, and I thank the chair for her willingness to bring the committee out here, and having this great testimony. Thank you.
>> Well, thank you, Mr. Honda, and I want to thank you for your participation, and he's a great member of the science committee, and really knows his stuff, and we're happy to have you on that committee. I would like to thank all of you. I hope that we will have a successful transformation of our energy system, in time to change the effects of global climate change. We will have a hearing on climate change in the near future when we go back in September. So I would like to thank both of our staff, the majority staff and the minority staff for all their hard work in putting this -- in putting this hearing together. It takes a lot of work, and you did a great job. And I want to thank our panelists for testifying before the subcommittee today. If there's no objection the record will remain open for members to add any follow-up questions that the subcommittee may ask of the panelists without objection. So ordered. This hearing is now adjourned.
>> Thank you Madam Chair. To the audience, you have an evaluation form, please turn in. If you park on the garage, we will validate your parking, down here on the left.